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XI. *The Construction and Use of Spherical Maps, or such as are delineated upon Portions of a Spherical Surface.* By Mr. John Colson, M. A. F. R. S.

GEographical Maps, and Hydrographical Charts, though they are Representations of a Convex Spherical Surface, yet were first delineated upon Planes, as being the most easy and obvious, tho' not the most natural and accurate Representations : And they will be sufficiently near the Truth, when the Part of the Earth or Seas to be described is not of a very large Extent. Such as these have been usually called Chorographical and Topographical Maps ; but when the Map is any thing general, or is to contain any large Tract of the Earth or Seas, suppose (for Instance) one of the four Quarters of the World, as they are call'd ; then, when they are projected, or represented upon a Plane, the Parts must necessarily be distorted, one way contracted beyond the Truth, another way dilated, so as to give no just Idea of the whole. Nor can this Distortion be possibly avoided, when any considerable Part of a Spherical Surface, by any Projection whatever, is to be represented upon a Plane. 'Tis true, this Distortion is always regular, and according to certain Laws ; so that knowing the Nature of the Projection, it may tolerably well be allow'd for. But to do this scientifically, and as it ought to be done, requires much Skill and Accuracy in the
 Maker,

Maker, as well as good Proficiency and Experience in the Peruser; and therefore not so proper for an Introduction to Learners, in the Rudiments of Geography. Young Minds are apt to receive wrong Notions and Prejudices from them, at least cannot be rightly and easily instructed by them.

To obviate this Inconvenience, Geographers have contrived and constructed the Terrestrial Globe, on which they endeavour to delineate all the Parts of the Earth's Surface in their natural State, as to Longitude, Latitude, Distance, Bearing, Magnitude, &c. which being a true and genuine Representation of the whole Superficies of the Earth, as far as it is yet known, is the best adapted for conveying just Notions to young Minds, and for preventing all false Conceptions and Prepossessions. After the first Rudiments of Geography have been imbibed from hence, they will be then prepared for the Use of plain Maps; and they will afterwards find, that large Projections of particular Countries, Kingdoms and Provinces, *in plano*, will be of excellent Service to them for their farther Improvement in this useful and necessary Science. Nor will they now be in any Danger of being misled by such Maps, tho' they are not so just and natural Representations of the Earthly Globe.

Now the same Conveniencies that may be derived from the whole Globe, may, in Proportion, be had from any notable Portions of it; as an Hemisphere, a Quadrant, a Sextant, an Octant, or other Part. But with this Advantage besides, that these partial Spherical Maps will not only be much less cumbersome, and more manageable than a whole Globe,

but may be made much more accurate and particular, as being capable of being form'd to a much larger Diameter than a Globe can conveniently be made to. The Maps may first be printed upon a Plane, as is usual in the common Globes, and then pasted upon thin convex Shells of Pastboard, form'd to the intended Radius. The forming of these spherical Coats of Pastboard will be a Matter of no great Difficulty, even to as large a Diameter as shall be desired; but the chief Art will be required in projecting the Maps *in plano*, after the simplest and exactest Manner, so as that they may adapt themselves, with as little Error as possible, to a spherical Surface. For a plane Surface cannot be converted into a spherical Surface without some Error. The best Method of doing this, with the least possible Error, I think will be as follows.

Instead of the usual Slips or Gussets, as is the manner of Globe-makers, which are comprehended between two Meridians at some Distance, and are form'd only tentatively and mechanically, without the Help of any just Theory, we may divide the whole spherical Surface into parallel Portions, or Zones; that is, into Parts terminated by two Parallels to the Equator, at the Distance (suppose) of ten Degrees. As if the first of these Portions, or Zones, were at the Equator itself, and extended to five Degrees of Latitude on each Side of that Circle, the second Zone would be at the Parallel of ten Degrees of Latitude, and would extend to five Degrees of Latitude on one Side, and to fifteen Degrees of Latitude on the other Side of that Parallel, and so of the succeeding Zones.

Now

Now we may conceive the first of these Portions, or Zones, to be converted from a spherical Surface to a plane Surface in this manner, without sensible Error. Let the middle Line of this Zone, that is the Equator, continue in its Situation, and let the Segments of the Meridians on each Side be conceived to unbend themselves gradually, 'till they are extended into right Lines perpendicular to the Equator: Then will that which was before a Zone, or Portion of a spherical Surface, with a small Alteration become a Portion of a cylindrical Surface, circumscribed about the Sphere; whose Breadth is every where equal to ten Degrees of the Sphere, and whose Circumference is equal to the Equator. And thus every Parallel to the Equator, as far as that of five Degrees of Latitude on each Side, will be stretch'd and extended into a Circle as large as the Equator; but they will all keep the same Distance from one another, and from the Equator, that they had before. This Extension, or Alteration, will be every where regular and uniform, and will be but very little, even where it is most: For the least of these Circles, which is the Parallel of five Degrees of Latitude, has the same Proportion to the Circle it is stretch'd to, or the Equator, as the Sine of 85 Degrees has to the Radius, or as 9961947 to 10000000; which approaches very near to a Ratio of Equality. And now it will be easily conceived, that without undergoing any other Alteration, or Distortion, this Portion of a cylindrical Surface may be rectified, or extended into a plane Parallelogram, whose Length will be equal to that of the Equator, and whose Breadth will be equal to an Arch of 10 Deg. of the same Equator.

And consequently, by an Operation that will be just the Reverse of this, if upon a Plane we delineate such a Parallelogram as this, we may then lay down all the Places that are contain'd in it very exactly, in their proper Situation of Longitude and Latitude ; and then apply its middle Line, or Equator, to that of a Globe of a due Magnitude, which will then become a Portion of a cylindrical Surface, circumscribed about the Globe. Then by pressing it close to the Body of the Globe, we shall cause it to contract itself a very little, but regularly, which Contraction will be only according to Longitude, and not at all according to Latitude ; and then the cylindrical Surface will be changed into that of a Sphere, and will become the first spherical Zone before described, with all its Delineations in their due Position, without sensible Error.

In like manner in the second spherical Portion, or Zone, comprehended between the Parallels of five and fifteen Degrees, whose middle Line is the Parallel of ten Degrees, we may conceive the Segments of the Meridians to unbend gradually on each Side, and to extend themselves into Tangent right Lines, which therefore will form a Segment of a conical Surface, still touching the Globe in the Parallel of ten Degrees of Latitude. The Axis of this Cone will coincide with the prolonged Axis of the Globe, and the Side of the Cone, which is to be estimated from the Vertex to the Circle of Contact, will be the Co-tangent of the Latitude, or the Tangent of 80 Degrees. Now this Portion of a conical Surface may easily be conceived to be unroll'd, or to be expanded into a plane Surface, without

out undergoing any other Alteration, and then it will become a Portion of a Sector of a Circle ; which Portion will have for its Length, or middle Line, an Arch of a Circle described with the aforefaid Tangent, as a Radius, whose Length will be the fame as the Parallel of Contact, and its Breadth will be equal to an Arch of the Equator of ten Degrees, as before. This Segment of a Sector of a Circle so produced, may therefore be easily described *in plano*, and within it may be inserted all the Places belonging to it, according to their Longitude and Latitude. Then it must be applied to the Globe, so as that its middle Line shall coincide with the Parallel of ten Degrees ; then by pressing it may be bent to the Surface of the Globe, every Meridian to its respective Representative, by which it will uniformly contract a little according to Longitude, but not at all according to Latitude. And thus the Globe will be cover'd as far as 15 Degrees of Latitude.

The next Zone, or that belonging to the Parallel of 20 Degrees, may be thus constructed *à priori*. Upon a plain Paper, with Radius equal to the Tangent of 70 Degrees, describe an Arch, whose Length is equal to that of the Parallel of 20 Degrees ; as also two other concentrick Arches on each Side, at a Distance from the middle Arch equal to an Arch of five Degrees. This will be the required Segment of the circular Sector, in which are to be inserted all the Places belonging to it, according to their Longitude and Latitude. Then the middle Line or Arch is to be apply'd to the Parallel of 20 Degrees upon the Globe, and the Segment of the conical Surface thence arising is to be duly contracted

tracted as before, or press'd close to the Globe; by which Means this Zone will also be compleated. And in the same manner we are to proceed to the succeeding Zones, 'till the whole Globe is cover'd. And the Method will not differ in any material Circumstance, if instead of a whole Globe, we are to construct any Part of it only, or what I here call a Spherical Map.

To reduce this Theory to Practice, and as a Specimen of Spherical Maps, I have constructed a Terrestrial Hemisphere to a Diameter of near 15 Inches: To which I have given the Name of the *British Hemisphere*, because it has *Great-Britain* in the Center, or rather at its Vertex. It is therefore adapted to the Meridian and Horizon of *London*, and exhibits one half of the Earth's Surface, as it lies round about this City; which is vastly the most considerable Part of the whole Earth's Superficies. The Longitude and Latitude of Places are here easily known by Inspection, and their Bearing and Distances may be nearly estimated: And all the Delineations are as accurate and particular as this small Radius would permit. I conceive therefore it may be no unfit Instrument for instructing Beginners, or for initiating young Minds in the first Rudiments of Geography.

F I N I S.

E R R A T A. Numb. 439. p. 145. l. 15. dele *Mr.* before *Pappus*.
P. 171. l. 4. for *Barrow*, read *William Barlow*,

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